

THREE important papers are reprinted by Mr. V. Ball, from the *Journal of the Asiatic Society of Bengal*—"Notes on the Geology of the Vicinity of Port Blair, Andaman Islands;" "Notes on Birds observed in the neighbourhood of Port Blair during the month of August, 1869;" and "Brief Notes on the Geology and on the Fauna in the neighbourhood of Naucowry Harbour, Nicobar Island."

THERE has been issued, under the auspices of the Accident Insurance Company, an admirable little manual of instruction for the prompt treatment of accidents and emergencies, by Mr. Alfred Smee, the eminent surgeon. It is clear, comprehensive, and portable, and the reader is guided in the more important curative processes to which it relates by well-executed and instructive woodcut illustrations.

"HUMAN Locomotion, how We Stand, Walk, and Run," is the title of a lecture delivered last December at Cornell University, by Prof. B. G. Wilder. Dr. Wilder's lecture was profusely illustrated by diagrams and interesting practical experiments. Among other matters he noticed the curious fact that a person never goes in a perfectly straight line for any distance, but always turns to one side or the other, and at last describes a circle and returns to the point from where he started. The deflection is generally if not always from right to left, and is accounted for on the principle that one side of the body tends to outwalk the other. It is a received opinion among American hunters and woodmen that people who lose themselves in forests or extensive plains thus travel in a circle turning to the left.

WE have received a pamphlet on the Economical Production of Peat and Peat Charcoal, as carried on at the works of the Peat Engineering Company, Redmoss, near Bolton, Lancashire. The peat is extracted from the bog, macerated, and moulded by machinery. It is also transformed into a superior quality of charcoal. That the manufacture is a profitable one is apparent from the fact that an acre of peat bog of the average depth of ten feet, will yield sufficient to make a thousand tons of charcoal, which, in competition with wood charcoal, can be sold at such a profit as would alone produce the value of the land from which it is extracted. It is stated that in 1852 the actual annual consumption of raw and carbonised peat in France amounted to 359,319 tons, a consumption which has since largely increased.

THE *Révue Universelle* says that the German Confederation, in acquiring an extended frontier from France, has traced it, not upon a topographical plan, but, in all probability, on a geological map edited at Berlin. In fact, it is to be observed that the new boundaries between France and Germany absorb, for the benefit of the Confederation, all the rich deposits of the mines of oolitic iron in the basins of the Moselle and the Meurthe, with the exception of the Longwy group. Save this, which has been reserved, Germany has made herself mistress of the major portion of the best part of the most important mineral beds in France. These beds extend under the vast plateau which forms the east of the departments of Moselle and Meurthe, and crop out in the valleys from Longwy, in the north, as far as Pont-Saint-Vincent (Meurthe), in the south, and comprise a full quarter of the mineral riches of France. The new determination of frontier will have the effect of introducing into the productive industry of Germany, according to the statistics of 1867, "twenty-three blast furnaces, producing 205,000 tons of metal; 9,000 hectares of iron country, yielding 500,000 tons of ore; fourteen works manufacturing 127,000 tons of iron; and 22,000 hectares of coalfield concessions, yielding 180,000 tons of coal."

THE Maharajah of Bhurtpore has established workshops in which steam is the motive power for the industrial instruction of his people.

ON THE STUDY OF SCIENCE IN SCHOOLS *

BEFORE we commence our regular and systematic study of science, I wish to say a few words to all of you who will hereafter take part in these studies, concerning the nature and character of experimental science, and certain matters connected with the pursuit of it. It will be well to discuss these subjects under the following headings:—

Firstly. The rise and growth of the sciences we are about to study, and their distinguishing features.

Secondly. The objects and aims of the experimental sciences, and the reasons why we study them.

Thirdly. The methods we shall follow for the acquirement of a knowledge of science.

Fourthly. The attitude of mind most favourable to such studies.

As to the first of these divisions, I may mention that the boundary lines of the experimental sciences are very clearly defined. For we find at the extreme limit in one direction the mathematical sciences, mathematical astronomy, mathematical mechanics, and so on; and at the other extremity the classificatory sciences: zoology, botany, and so on. Our course lies between the two limits, where we find the physical sciences proper: statics, dynamics, mechanics, hydrostatics, hydrodynamics, pneumatics, acoustics, heat, light, magnetism, electricity. Chemistry is usually distinguished from these; both on account of the magnitude of the science, which necessitates separate and distinct treatises, and because it concerns the intimate structure or composition of matter, while the physical sciences proper are concerned with unaltered matter. But the term experimental sciences includes both the physical sciences and chemistry, and is hence the most convenient for our purpose.

Most of the physical sciences partake somewhat of the character of the mathematical sciences, while chemistry is on the verge of the mathematical sciences. The physical sciences relate rather to dead matter, to inorganic, unorganised matter, while the classificatory sciences relate to organised living matter: the former to the mineral kingdom (as it used to be called), the latter to the animal and vegetable kingdoms.

Although isolated facts belonging to many of the sciences were known to the ancients, no science can be said to have existed in anything like a complete form for more than 200 years, and several of them are less than a century old. The science of *Statics* treats of the balance of forces, of the relation of the various forces which act upon solid matter at rest. The derivation of the name from *ῥατῆμι* is sufficiently obvious. The science commenced with Archimedes (who lived in the third century B.C.), and was greatly developed by Galileo, Bernoulli, and Lagrange. When the equilibrium of fluids is discussed, it is called *Hydrostatics* (from *ὕδωρ*), and the equilibrium of gases is described under the head of *Pneumatics* (*πνεῦμα*). Hydrostatics owes its origin to Archimedes; you will remember the story of his weighing the crown of impure gold in water, and detecting the imposture; and thus arose that which to this day is called the "law of Archimedes," which asserts that when a body is immersed in a liquid, it loses a portion of its weight equal to the weight of the liquid which it displaces. Stevinus of Bruges, who wrote in the sixteenth century, and Pascal contributed much to the advancement of this science. The reverse of rest is motion, thus there are sciences relating to the motion of solids, liquids, and gases. *Dynamics* (*δύναμις*) treats of the motion of solid bodies, and of the relation of the forces which produce motion. It originated as a science with Leonardo da Vinci, who, besides being the greatest painter of his day, was an eminent mathematician, engineer, musician, and natural philosopher. He showed that if two forces are represented in magnitude and direction by the two sides of a parallelogram, the resultant is represented by the diagonal of the parallelogram. This is the important principle of the "parallelogram of forces." Galileo added the laws regarding falling bodies; while Newton and Huyghens investigated the laws which regulate centrifugal forces. *Hydrodynamics* treats of the motion of fluids, and bears the same relation to dynamics that hydrostatics bears to statics. The motion of gases is discussed under the science of pneumatics; we have no sciences of pneumastatics and pneumodynamics. Pneumatics dates from the discovery of Torricelli in 1642 that the air possesses weight. Eight years later, Otto von Guericke, of Magdeburg, invented the air-pump, and the science was then developed with great

* A Lecture delivered at Marlborough College as an introduction to the commencement of Science teaching, by G. F. Rodwell.

rapidity. Before the end of the century various treatises on pneumatics had appeared, and perhaps no science so speedily reached maturity. The above sciences, it will be noted, relate to the properties of matter in its three forms of solid, liquid, and gas, when at rest and in motion. We come next to certain sciences which treat of the more subtle and intimate motion of the particles or molecules of matter, with various velocities and in various directions. Beginning with *Acoustics*, we have the vibratory motion of particles across a position of rest resulting in the production of what we call sound. The science of sound, although more or less linked with the art of music, has existed as an experimental science for less than a century. Vibratory movements of the same character taking place in a subtle kind of matter called the ether or interstellar medium, constitute *Heat* and *Light*, the difference being one of velocity, and thus of degree rather than of kind. Finally, we may assume that *Magnetism* and *Electricity* are conditions of matter perhaps not differing much from those which constitute light and heat.

The science of *Light* is certainly one of the older of the sciences. Euclid endeavoured to explain the laws of vision; Ptolemy, the astronomer, wrote a treatise on *Light*; the reflection of light by mirrors, and its refraction by lenses, were well known facts in the time of Archimedes. Various treatises on the subject appeared during the Middle Ages. The *Ars Magna lucis et umbræ* of Athanasius Kircher, published in the seventeenth century, is a great folio, full of plates. Not long after its publication Newton made the important discovery of the decomposition of light, and treated various optical problems with great precision by mathematical means. Our term *light* is related to the Sanskrit *lok*, to see. Heat has not existed as an experimental science for a century. The science has made great progress during the last thirty years. Heat was once believed to be an entity, a kind of matter, which passed from one substance to another, and which effected certain changes during its transference. We now know that it is simply a kind of motion akin to that which constitutes light, so that it ceases to be matter, and becomes an attribute of matter. It is strange that the term *heat* should be far more appropriate now than it was when heat was regarded as matter, although it was in use long before any theory or science of heat existed. The term appears to be derived from the Sanskrit *indh*, to kindle, through the Greek *αἴθερ*, the Latin *æstus*, and the old High German *eit*. "*Æstus*," says Vossius, "est commotio vel in aqua, vel in igni, vel in animo, omnis autem commotio fervorem gignit." And the result of modern research has been to prove that what we call heat is, indeed, due to a commotion of particles of matter. Certain properties of heat were well known to the ancients, although the science itself is so young. Thus, Pliny states that the sacred fire of Vesta was kindled by reflecting the rays of the sun by mirrors. The story of Archimedes and the Roman fleet is well known to you. Lenses were known and were used as burning glasses. Aristophanes clearly alludes to the use of a glass lens for obtaining fire; a lens was found among the ruins of Nineveh, and is now in the British Museum. Lactantius states that fire may be kindled by passing the rays of the sun through a glass globe filled with water.

Magnetism has existed for about 270 years as an experimental science. A few magnetic experiments are mentioned by Lucretius, and by Pliny, and one or two Middle Age writers allude to the effects. Of course the mariner's compass, which was known in Europe in the twelfth century, called attention to the existence of the so-called magnetic force. The birth of the science dates from the publication by Gilbert of Colchester of a treatise entitled "*De Magnete*," in 1600.

Thales, of Miletus, observed that amber when rubbed acquired the property of attracting light substances, and as the Greek for amber is *ἡλεκτρον*, and the effect had not been observed in other substances, a new science arose called *Electricity*; but the science has scarcely existed for more than 200 years. The inventor of the air-pump, Otto von Guericke, was also the inventor of the electrical machine. Thus *Pneumatics* and *Electricity* were called into existence at almost the same time. Note how essential the invention of apparatus has been to the different sciences. Until experiments could be tried, and until instruments were devised for trying them, the natural sciences made no progress. *Voltaic Electricity*, or *Galvanism*, dates from the commencement of this century, and *electro-magnetism* and *dia-magnetism* are yet later developments.

We learn from the above remarks that, although some of the fundamental facts of various sciences were known to the ancients, they never developed them. In fact, there was no experimental

science among the ancients, they by chance lighted upon a few solitary facts, and with these they were well content. There could be no experimental science among them, for the fundamental feature of this kind of knowledge is, that it depends upon the action of the mind upon matter, while the ancients preferred to exercise their intellects upon things not external to themselves. Physical philosophy is distinguished from mental philosophy by the fact that the former is based upon observed results obtained by the action of the mind aided by experiment, upon external matter, while the latter is based upon the actions of the mind upon itself according to definite laws instituted by the unaided intellect. The ancients elaborated the most admirable systems of mental philosophy, but they refused to have anything to say to experimental philosophy. We may take the following remarks of Seneca as to some extent an exemplification of the spirit in which the ancients regarded Natural Philosophy:—"The astronomer tells me of Saturn and Mars in opposition, but I say, let them be as they will, their courses and their positions are ordered them by an unchangeable decree of fate. Either they produce and point out the effects of all things, or else they signify them. If the former, what are we the better for the knowledge of that which must of necessity come to pass? If the latter, what does it avail us to foresee what we cannot avoid? So that whether we know or not know, the event will still be the same;" as if he said in the language of more modern science, "I am assured that the specific gravity of iron is somewhat more than that of manganese, and somewhat more than that of copper, but I know they are immutable, and it hence matters not how they differ." Or again, "I am told that there are iron and sodium in the sun, but I can never be there to verify it, therefore it cannot concern me." The ancients were content with the truths which they possessed, and cared not to seek for the discovery of new truths. Thus, as I before said, they possessed no system of experimental science.

You will perhaps ask me why physical truths cannot be discovered by means of the unaided intellect. Why is experiment necessary? We must remember that our senses, although infinitely more perfect than our most delicate and refined scientific instruments, are limited in their capabilities. They are devoted to the service of our organisms, and exist for the purpose of enabling us to fulfil all the conditions requisite for the maintenance of life, and to make us cognisant of the external actions of the material world. But this latter function they exercise only to the necessary extent. There are numberless phenomena beyond the direct cognisance of the senses; there is, if I may so express it, light which is unseen by the eye, sound which is unheard by the ear, heat which is unfelt by the nerves of touch. I mean there are physical actions of the same nature as those which constitute light, sound, and heat, which we cannot directly recognise. It then becomes necessary to call in the aid of experiment and of various instruments to assist and exalt the action of the senses. We have a familiar example of this in the microscope. A speck which the unaided eye recognises with difficulty, is seen by exalting the capabilities of the eye in one particular direction to be a perfectly organised being, possessing many of the functions of creatures far higher in the scale of animal life. One of the Infusoria measures about the twenty-two thousandth of an inch in diameter, and can only be seen by the aid of a powerful microscope, yet it is a perfectly-organised creature. So also, when we wish to examine the various properties of matter, it is absolutely necessary for us to aid the intellect and the senses by means of instruments and experiments. The properties of matter were utterly unknown to the ancients, because they relied upon the unaided intellect, and disdained experiment. Numberless effects in nature reveal themselves only when an unnatural and forced condition is imposed upon matter. "*Occulta Naturæ*," says Francis Bacon, "*magis se produnt per vexationes artium quam cum cursu suo meant.*"

Although many observers existed before the seventeenth century, there were but few experimenters. Observation, experiment, and reasoning, must go hand in hand, before experimental science can progress. We first find this combination in a very marked degree in Galileo, a professor in the University of Pisa, who was born in 1564, and wrote in the early part of the next century. He invented the telescope and thermometer; demonstrated the theory of Copernicus, which asserted that the sun is the centre of our system, and that the earth moves round it; discovered the satellites of Jupiter and the spots on the surface of the sun, and, in a word, made the first real progress in many of the sciences. Galileo is often called the "*Father of the Experimental Sciences*;" it is certain that he was the first experi-

mental philosopher worthy of the name. The science work of the seventeenth century was altogether prodigious; at no time has so much been effected; indeed the greater number of the sciences sprang into existence at this time.

Science was greatly promoted by the establishment of Scientific Societies about the middle of the century. Literary Societies had existed in Italy long previously; these consisted of a number of members who met together at stated intervals for the discussion of literary matters, the recitation of poetry, and the reading of essays. The names of some of these societies were sufficiently curious; thus we find, among others, the following:—the Grieved, the Fiery, the Dispirited, the Solitary, the Rough, the Unripe. Battista Porta founded the first scientific society in 1560, and called it the “Academy of the Secrets of Nature;” but on account of the privacy of the meetings, and the prevalence of occult and forbidden arts at this time, it came to be believed that the members used magical and diabolical influences, and the society was dissolved by the Pope. Shortly afterwards Porta published his “Natural Magic,” in which he endeavours to prove that the magic of Nature is as wonderful as the magic of Art; in a word, that we find in the phenomena of Nature results quite as wonderful as those produced by professed sorcerers. After the dissolution of Porta’s Academy, we find no scientific society until the formation of the Academy of Cimento in Florence, in 1567. This Society was not founded for the discussion of theoretical, or even simple observational science: “our sole design is to make experiments and to relate them,” says the secretary at the commencement of the proceedings. Consequently, although the Society flourished for no more than ten years, a volume of “Experiments made in the Academy of Cimento” appeared in 1667, and from its importance it was speedily translated into Latin, and into most of the languages of Europe. It contains a number of experiments relating chiefly to pneumatics and heat.

About the year 1658, a few Oxford men, interested in science, agreed to meet in each other’s rooms once a week for the trial of experiments, and for the discussion of scientific matters. The number of members increased, and after a while the meetings were removed to London, and were held in Gresham College. Soon afterwards the society was incorporated by Charles the Second, under the name of the “Royal Society for Promoting Natural Knowledge.” Note the significance of the term *Natural* as here employed. There was so much unnatural science in the world, so much magic, witchcraft, false knowledge, that the society thought it well to specify “Natural Knowledge.” We find traces of the magical lore of the age in the accounts of early meetings of the Society; thus we find in the minute-book of the Society the following entries under the year 1660:—

“June 5th. His Grace the Duke of Buckingham promised to bring into the Society a piece of an unicorn’s horn.

“July 14th. A circle was made with powder of unicorn’s horn, and a spider set in the middle of it, but it immediately ran out several times repeated. The spider once made some stay upon the powder.

“June 26th. Dr. Ent, Dr. Clarke, Dr. Goddard, and Dr. Whistler, were appointed curators of the proposition to torment a man presently with the sympathetical powder.

“June 10th. The fresh hazell sticks were produced, wherewith the divining experiment was tried, and found wanting.”

This Society continues to meet weekly, and in its Transactions may be found all the most important scientific memoirs which appear in this country. The Académie des Sciences was founded in Paris a few years after the Royal Society of London.

The influence of scientific societies on the influence of experimental science has been, and still is, very considerable. Towards the end of the seventeenth century they were very generally dispersed throughout Europe, and experimental results accumulated at a rapid rate. They were embodied in text books, and were soon introduced into the Continental universities, and thus became incorporated with general learning. No place in the world has taken so prominent a part in the furtherance of experimental science as the University of Leyden. Its professors during the seventeenth century were renowned throughout Europe, and students flocked from every part of the Continent to the University. Again, it is a noteworthy fact that the first text book of physical science, and the first text book of chemistry, both issued from this university:—the *Physices Elementa Mathematica* of S’Gravesande, and the *Elementa Chemiæ* of Boerhaave. They each consist of two well-illustrated quarto volumes, and were published during the first half of the last century. The greater number of the sciences are made up of the discoveries of the last

two centuries, and these will come under our notice when we study the special science itself. I may, therefore, safely leave our brief survey at this point.

(To be continued.)

SCIENTIFIC SERIALS

THE *Révue Scientifique* Nos. 8—12 has been to a large extent occupied by a report of the most important papers read at the recent meeting of the British Association; but we find in addition the following valuable articles:—A report of the very important course of lectures delivered by M. Claude Bernard at the Collège de France “On the Action of Heat on Animals;” report of a course of lectures by M. Gréhant “On the Renewal of the Air in the Lungs,” largely illustrated by woodcuts; a paper by M. Onimus on *Les nerfs trophiques*; and a number of other papers chiefly bearing on physiological subjects, either translated from the English, or extracted from the proceedings of learned societies. Copious extracts from Mr. Darwin’s work “On the Descent of Man” are also translated from time to time.

Der Naturforscher, Nos. 31—34, August 1871. This journal is entirely made up of articles and abstracts from German, French, English, and Italian serials. Some of the latter are especially interesting to us, as being less known in this country. In the first number we find some researches by Prof. Nobbe of Tharand on the function of potassium salts in the nutrition of plants. The experiments were made on buck-wheat and rye; they led to the conclusion that potassium is quite indispensable to the assimilation of plants; without it no starch is formed in the chlorophyll-granules, and the weight of the plant remains constant, exactly as in pure water. Neither sodium nor lithium can replace potassium, the lithium being positively pernicious. An article giving the results of the second German Arctic Expedition describes the climate of East Greenland, where the ground appears to be for three months free from snow, and covered with abundant herbage, fed upon by the reindeer and the musk-ox. The latter was not before known to inhabit this region. From an account of the water supply and soil of the town of Zurich, we learn that in the cholera epidemics of 1855 and 1867, no confirmation could be found of Pettenkofer’s theory with respect to the connection of cholera and “Grundwasser.” Prof. Nöbels of Kiel, discusses the nutrition of deep-sea animals, especially in relation to the organic “slime,” which he believes to be chiefly of vegetable origin. Prof. Karsten related to the Austrian Pharmaceutical Conference in Vienna his personal experience of the poisonous properties of the famous manchineel tree (*Hippomane manzanilla*) of the West Indies and tropical America, which have been doubted by some naturalists. Being engaged for some hours in collecting its juice, Karsten was attacked with burning sensations of the skin, swelling of the face, eyes, &c., which compelled him to pass three days in total darkness. He attributes these effects to a volatile poison given off by the tree. Other papers are: Nyland “On the Phenomena of Discharge of Induced Currents of Electricity;” Fritsch “On the Geological History of the Santorin Group;” Meunier “On the Cosmical Relations of Meteorites, and the Black Colouring Matter of the Meteorite of Tadjera;” Secchi “On the Solar Protuberances;” Young “On the Corona;” Klocke “On the Growth of Crystals,” &c. The following papers on physics are from journals little read in England:—“The Heat given off by Incandescent Platinum,” by Prof. Garibaldi of Genoa. He used, as Tyndall in his experiments on the electric light, a thermopile, but let the rays pass through a dry vacuum tube closed with thin plates of rock-salt, and absorbed the light rays by a solution of iodine in carbon disulphide. In this way the errors arising from the passage of the rays through a moist atmosphere and through prisms and lenses of rock-salt are avoided. He finds the ratio of visible and invisible rays given off from white hot platinum 1 : 25; but there was still some loss of the dark rays. (*Il nuovo Cimento*; ser. 2; tom. iii.) In another research, Garibaldi has investigated the power of absorption for heat of the constituents of the atmosphere. The source of heat was heated platinum, and radiation took place through a closed vacuum, thus avoiding some of the errors of other experimenters. The power of absorption possessed by aqueous vapour was found to be 7,937 times that of dry air. A valuable paper by Kundt (“Würzburger Verhandlungen,” Neue Folge, vol. iii.), discusses the anomalous dispersive power for particular parts of the spectrum possessed by certain coloured substances as hæmatin, chlorophyll, sandal wood, litmus, &c.